APPENDIX F

FOREST ROADS

Introduction

In forested watersheds throughout the Pacific Northwest, logging roads are a significant source of sediment (Megahan and Kidd, 1972; Cederholm and Reid, 1987; Chamberlin et al., 1991; Nolan and Janda, 1995; Bolda and Meyers, 1997). Roads are considered the main cause of accelerated erosion in forests across the western United States (Best et al., 1995; Harr and Nichols, 1993). This reflects a legacy of roads built under varying ownerships and Forest Practices Rules. Many chronic sources of sediment in Washington State are from old, poorly built roads.

Processes initiated or affected by roads include landslides due to road prism failure; road surface erosion; secondary erosion (landslide scars exposed to rainsplash); and gullying. "Road prism" refers to the cross-sectional configuration of a road, which includes the roadbed (sometimes called tread), a road cut, and/or a road fill. Additionally, roads may change the hydrology of streams by extension of the drainage network and road ditches can divert water from one stream basin to another. Section 3.3.2.3 of the EIS discusses these effects further.

Road prism failures are present in most managed, forested watersheds in Washington State. Furniss et al. (1991) found that forest roads contributed more sediment than all other forest activities combined, ranging from 26 to 346 times the volume of sediment produced in undisturbed forests, on a per-unit basis. These types of failures typically occur along steep valley sideslopes and when stream crossings fail. Failure of the fill slope is usually a result of overloading of the existing slope with the added weight of the fill material, or as a result of roads being built on unstable soils. Stream crossing failure usually occurs when a culvert becomes plugged up with debris, impounding water behind the road prism. Either the water may overtop the road, incising down and causing collapse of the adjacent road prism, or it may cause the roadbed to be saturated, and slough off the hillside due to the excess weight.

Road cuts may also fail; this is primarily in response to the removal of material for road construction. When a road cut fails, the mobilized sediment is usually deposited onto the road. This sediment may block flow within a ditch, leading to further erosion of the road prism as water in the ditch flows around the failure. Road cuts also commonly collect flow from hillsides, usually in the form of springs exiting at the road cut. This water may then flow down the uphill ditch, adding extra flow volume in adjacent streams. This may also lead to road prism failure.

Road surface erosion is particularly affected by traffic (Reid and Dunne, 1984). Sediment yield increases substantially with increases in traffic. This type of erosion is also dependent on road surfacing and road drainage. For example, a paved road will produce much less sediment than one with no surfacing (Washington Department of Natural Resources, 1997).

To assess the effects of roads, the regulations regarding road construction and maintenance must be examined. Roads built following Forest Practices Rules that provide specific direction and recommended BMPs from the literature have the lowest risk of causing sediment delivery. The following section describes recommended and accepted practices for building and maintaining forest roads.

Recommended Forest Road Construction and Maintenance Practices

Various researchers, agencies, and landowners now recognize practices that help reduce sediment delivery from roads to streams. In this section, recommended practices will be summarized. In the following section, each of the alternatives will be compared to these practices to evaluate their efficacy. Many of the practices presented in this section were derived from Weaver and Hagans (1994), which was recently incorporated into a habitat conservation plan approved by the National Marine Fisheries Service (PALCO, 1999).

In addition, a study conducted by the Department of Ecology and Timber, Fish and Wildlife (Rashin et. al., 1999) concluded that many current BMPs were not effective at preventing chronic sources of sediment delivery. Some of the main deficiencies noted were delivery of water and sediment to streams from ditch relief culverts, erosion of newly constructed roads at stream crossings (current erosion control measures were rated ineffective); and poorly installed culverts that block fish passage. Recommendations from this report are reflected in Table 1. This section is organized by the major aspects of road management: planning, design, drainage, construction, and maintenance and abandonment.

Road Planning

Road planning is one of the most important ways in which sediment delivery from roads can be reduced (Yee and Roelofs, 1980). Minimizing the amount and size of new roads greatly reduces the risk of sediment delivery from roads.

In identifying the route of a new road, the slope of the land is one of the first parameters considered. Road segments greater than 500 feet in length should not have slopes greater than 15 percent. Additionally, roads that traverse steep slopes create large lengths of cutslope and fillslope; thus, it is important to avoid the steepest slopes when laying out a road system. This reduces the risk and effects of fillslope failure and other erosional processes, although in some locations may lead to greater total road length.

The natural slope stability must also be considered. This includes examining such features as orientation of bedrock joints and bedding planes, degree of weathering, moisture, and rock hardness.

Drainage is also important in planning. Poorly drained soils should be avoided. Since stream crossings provide the linkage between habitat and road-derived sediment, roads should be planned to minimize the number of stream crossings.

Table 1. Summary of Recommended and Actual BMPs for Road Management, by Alternative*

Road Management Aspect	Recommended Practice [1,2,3]	Input/Process Affected	Alternative 1 (Current Permanent Rules)	Alternative 2 (Forests and Fish Report)	Alternative 3 (Tribal/WEC Alternative)
Planning	Minimize total road length and width, stream crossings	Road surface erosion, road failures, fish passage	Encouraged	Encouraged	No net increase in road length
	Avoid unstable or steep slopes, saturated soils	Road failure, road surface erosion	Yes; agency review if unavoidable	Yes; more intensive review if unavoidable	Yes; more intensive review if unavoidable
	Avoid locating landings in sensitive areas	Road failure	Mentioned, but specific areas to avoid not identified	Mentioned, but specific areas to avoid not identified	Mentioned, but specific areas to avoid not identified
Design	Minimize cut and fill slopes	Road surface erosion, road failures	No	Yes	Yes
	Outsloping preferred	Road surface erosion	Yes	Yes	Yes
	Full bench on >60% slope	Road failure	No	Yes	Yes
	Minimize sidecast construction	Road surface erosion	No	No	No
	Culvert at stream grade**	Fish passage	Yes	Yes	Yes
	Culvert along natural alignment**	Fish passage	Yes	Yes	Yes
	Pool at outlet**	Fish passage	No	No	No
Drainage	Rolling dips, water bars	Road surface erosion, road failures	Not required	Not required	Not required
	18” corrugated metal pipe (CMP) ditch relief culverts, spaced appropriately	Road surface erosion	Required, but at distances greater than recommended by literature	Required	Required
	Culvert outfall protection	Road surface erosion	Encouraged	Encouraged	Encouraged
	Grade dips at stream crossings	Road failure	No	No	No
	Install trash racks	Road failure	No	No	No
	Culvert sizing – 50 year flood or greater, rational method	Road failure	50-year flood; “technical engineering” methods recommended for culverts > 3’ diameter	100 year flood; “technical engineering” methods recommended for culverts > 3’ diameter	100-year flood; “technical engineering” methods recommended for culverts > 3’ diameter
Construction	Erosion control during construction	Road surface erosion	Encouraged near type 1, 2, and 3 water; rated ineffective	Encouraged regardless of proximity to water	Encouraged regardless of proximity to water

Table 1. Summary of Recommended and Actual BMPs for Road Management, by Alternative* (continued)

Road Management Aspect	Recommended Practice [1,2,3]	Input/Process Affected	Alternative 1 (Current Permanent Rules)	Alternative 2 (Forests and Fish Report)	Alternative 3 (Tribal/WEC Alternative)
Construction (continued)	Careful sidecast placement	Road surface erosion	Yes; not within 50-year flood level	Yes; not within 100-year flood level	Yes; not within 100-year flood level
	Minimize amount of soil disturbance	Road surface erosion	No	No	No
	Construction during dry conditions	Road surface erosion, road failure	Encouraged	Encouraged	Encouraged
	No organic matter in fill	Road failure	Yes	Yes	Yes
Abandonment	Maintenance and abandonment plan required	Road surface erosion, road failures, fish passage	Required only upon DNR request	Yes	Yes
	Remove culverts & fill at stream crossings	Road failures, fish passage	Upon notification of landowner by DNR	Yes	Yes
	Scarify, seed, and mulch	Road surface erosion	No	No	No
	Abandon orphan roads	Road surface erosion, road failure	No	Inventory, assessment required	Inventory, assessment required
	Pull back landings above streams	Road surface erosion, road failure	Landings above streams not allowed	Landings above streams not allowed	Landings above streams not allowed
	Prioritize roads blocking passage	Fish passage	No	Yes	Yes
Maintenance	Pre-wet season inspection	Road surface erosion, road failure	No	No; requires “pre-storm planning”	No; requires “pre-storm planning”
	Ditch maintenance	Road surface erosion, road failure	Yes	Yes	Yes
	Appropriate amount of ditch maintenance	Road surface erosion, road failure	No	Yes	Yes
	Clean trash racks	Road failure	No	No	No
	Maintain pool at culvert outlets**	Fish passage**	No	No	No
Overall risk of sediment delivery* **			Moderate to high	Moderate	Moderate to low

* Note that this table does not include all possible BMPs. It lists the BMPs deemed most important in Weaver and Hagans (1994), Rashin et al. (1999).
** These BMPs are also regulated by Washington Department of Fish and Wildlife.
***Overall risk of sediment delivery includes risk of delivery of sediment from both surface erosion and mass wasting.
[1] Weaver and Hagans, 1994
[2] Rashin et. Al., 1999
[3] Yee and Roelofs, 1980

Landings may also cause landslides in forested terrain. As with roads, the number and size of landings should be minimized. When planning the location of landings, the following areas should be avoided: 1) steep headwater swales; 2) inner gorges; 3) narrow ridges between headwater swales; and 4) slopes greater than 50 percent that are directly above a stream or wetland.

Road Design

One of the most important aspects of road design is the shape of the road prism. Components of the road prism include the roadbed, the cutslope, and the fillslope. A road can either be full bench, partial bench, or full fill. Generally, on slopes over 60 percent, roads should be designed as full-bench, meaning that the roadbed is cut into the hillside, and the roadbed is composed of undisturbed, in-place materials (Weaver and Hagans, 1994). With full-bench construction, all excavated material is hauled away for use or disposal elsewhere.

Partial bench construction (also known as sidecast construction), is the most common type of road construction, and is associated with the most damage to aquatic systems. In general, sidecast construction should not be used on slopes over about 60 percent, and should be limited to gently sloping areas far from streams.

Cut-and-fill slopes can also be designed to minimize erosion and failure. Cutslopes should be as steep as the soils and bedrock permit without becoming unstable. The road width often determines the height of the cutslope, and should, therefore, be minimized. Fill slopes can be built at various angles, depending on the properties of the soils and the building techniques used (including compaction and re-enforcement with engineered materials). However, loose, uncompacted sidecast should generally not be used at an angle of 60 percent or higher (Weaver and Hagans, 1994).

Design of the road surface has proven critical to reducing road surface erosion. An important parameter is the slope of the road perpendicular to the hillside. Forest roads can be insloped or outsloped. The ditch intercepts water from the road, which tilts gently toward the ditch, and from the cutslope. The ditch grade should be between 2 and 6 percent where possible. This is steep enough to keep water flowing, but not enough to cause scour in the ditch. On insloped, ditched roads, frequent ditch relief culverts (cross-drains) should be used. Cross-drains divert water from the ditch, under the roadbed, and onto a stable slope below the road. The spacing of cross-drains depends on the road grade, and the erodibility of the hillslope onto which the culverts drain (see Table 20 in Weaver and Hagans, 1994). A minimum culvert diameter of 18 inches is recommended. Cross-drains should be installed at a grade 2 percent higher than the grade of the ditch, and at an angle of 30 degrees relative road alignment. Ditches should be designed to accommodate the same level of flood as the streams to which they deliver. Cutslopes, ditches, and relief culverts should all be designed so that runoff is directed onto stable, vegetated areas where sediment will be filtered out.

A highly recommended technique for reducing road surface erosion is outsloping. On an outsloped road, there is no ditch on the upslope side of the road. Instead, the road surface gently tilts away from the cutslope, between 3 and 8 percent, depending on the road grade. In place of ditch relief culverts, grade dips are recommended. These are low spots in the road spaced frequently enough to prevent channelized flow on the road surface. They are built with very gentle inclines to allow vehicles to pass over them without slowing significantly. Notably, outsloping may be inappropriate where the soil is highly erodible.

Landing design is also critical in minimizing sediment production. They should be designed with a minimum of sidecast, and with no organic debris.

Road Drainage

There are two components of drainage design practices: hillslope drainage and stream crossings.

Hillslope drainage refers to water draining from the upslope side of the road. It may emanate from swales or from groundwater intercepted by the road cut. Designing for hillslope drainage mainly involves the sloping of the road surface and ditches and relief culverts; these measures have been discussed above.

Stream crossings are the primary delivery route for road-generated sediment (Duncan et al., 1987). It is thus critical to design stream crossings to minimize delivery of sediment. In addition, in fish-bearing streams, it is critical to maintain fish passage.

Stream crossings should be designed to minimize the potential for stream diversion, which occurs when the road is overtopped, and water flows down the road or road ditch, instead of back into the natural channel. To accomplish this, grade dips should be installed slightly off the culvert centerline (Weaver and Hagans, 1994).

For fish passage, culverts at stream crossings must have sufficiently gentle grade to permit flow velocities low enough for fish to swim upstream. Culverts should be placed at or slightly below the grade of the existing channel, and should be in alignment with the channel. Culverts should also be placed to ensure that the water depth is sufficient for fish passage. There should also be a holding pool below the culvert outlet, which allow fish to rest before swimming up the fast moving water in the culvert. Although WDFW regulates fish passage on individual crossings through the HPA process, the DNR is also involved in the regulatory process through establishment of basin-wide performance-based rules that include specific objectives for fish passage.

To prevent overtopping, Weaver and Hagans (1994) recommend the use of debris control structures (also called trash racks) are crucial on streams with high debris carrying potential. Installed on the upstream side of a culvert, or bridge, trash racks may be composed of anything from a series of wood posts installed side by side, to steel grates. Notably, trash racks may actually cause failure on stream crossings where small debris clogs the rack and water cannot pass quickly and in some cases have presented a barrier to fish, which highlights the need for careful maintenance.

Culvert capacity is critical in preventing overtopping as well. In Oregon and Washington, existing permanent Forest Practices Rules use the 50-year flood level to size culverts. However, in Washington State, the WDFW has required sizing for the 100-year flood on fish-bearing streams. To calculate the 50-year flood, the “rational method” is recommended (Weaver and Hagans, 1994). As the expected life of the culvert increases, the likelihood of a flow exceeding the 50-year level increases. Consequently, the 100-year flood may be more appropriate for sizing long-lived culverts. Except for the smallest culverts, crude estimation of culvert size is discouraged. Culverts should also be of sufficient length to pass the water and debris into the stream channel; culverts that are too short may erode the fill adjacent to the roadbed. In addition, a rocked outlet provides protection against scour from the water exiting the culvert.

Bridges offer an alternative to filled stream crossings, such as those with culverts. Temporary, 'portable' bridges are ideal for fish passage and for minimizing sediment delivery at stream crossings.

Road Construction

The two most important aspects of road construction with regard to sediment delivery are timing and erosion control measures.

Road construction should be limited to the dry season. Stream crossings in particular should be built when the water is at its lowest level; this minimizes the risk of sediment delivery.

Erosion control during construction includes a suite of activities. As a basic rule, soil disturbance should be kept to a minimum. Any large exposed soil slopes to be left permanently should be seeded and mulched immediately. These may include fill slopes, or spoil piles. If standard erosion control materials are recommended, such as silt fence or straw bales, it is critical that they are installed correctly, and that adequate maintenance is planned and provided.

Road Abandonment

The definition of road abandonment varies from not using a road to removing stream crossings and roadbed to match the original topography. Roads that are no longer used or maintained are likely to continue to deliver sediment to streams (Brunengo and Bernath, 1990) and an effective road management plan must provide for proper abandonment. A key determinant of "proper" abandonment is whether a road segment has been sufficiently treated so that maintenance is no longer necessary to prevent sediment delivery.

Road abandonment programs minimize the risk of sediment delivery in a given watershed. The degree to which delivery risk is reduced depends on the extent and specificity of the program.

One of the primary treatments is to remove stream crossings, thus preventing overtopping of the roadbed. When removing a stream crossing, the streambed should be restored to at least the original width, and preferably to a slightly larger width.

Another key component of abandonment is the identification and treatment of unstable roads and landings. These areas should be excavated and graded to prevent landsliding onto nearby streams. This usually involves using heavy equipment to pull back the unstable fill, and then disposing of the fill in a stable area.

Waterbars should be installed on abandoned roads to prevent rilling in the roadbed. The road should also be scarified to a depth of at least 15 inches, to aerate the compact surface and enhance growing conditions, then seeded or planted. The road surface should be outsloped, and ditches eliminated, eliminating the need for ditch maintenance. Seed mixes and plant species should be approved by a local conservation district, and should be composed of non-invasive species. When combined, these measures eliminate the need for any maintenance.

Road Maintenance

Maintenance is an essential part of road management. If funding for adequate maintenance is not sufficient for a proposed road, the road should be planned as a temporary road to be abandoned at the first opportunity after completion of harvest operations.

Maintenance begins with consistent inspection, or monitoring, of road conditions. Inspection should be conducted at least once a year, and well before the onset of the rainy season. Inspection during the wet season may facilitate identification of maintenance issues. In addition, road maintenance crews should be on hand during the rainy season to respond to large storms.

One major rule of maintenance that should be followed is to grade road surfaces and clean ditches only when necessary. This minimizes road surface erosion, loss of road surfacing, and scour in the ditches.

Temporary roads, and unsurfaced permanent roads, should not be used during wet conditions.

Cutslopes should be inspected for instability which has or which could cause blockage of the ditch. Any ditch blockage that has occurred should be properly cleared. Fill slopes should be inspected for tension cracks. Such fill slopes should be stabilized by removing the sloughing sidecast, and any organic material that may be present in the roadbed. Any spoils created during road maintenance should be disposed of in a stable location away from steep slopes and from streams.

Comparison of Alternatives

This section compares the alternatives as to their effectiveness in reducing the risk of sedimentation due to road construction and maintenance. As mentioned previously, fish passage is an issue jointly regulated by the WDFW. The WDFW issues Hydraulic Project Approvals for new stream crossings, while DNR policy (particularly under Alternatives 2 and 3) includes fish passage as an objective and the rules developed for forest practices must be consistent with WDFW requirements. To provide background for the analysis, a brief discussion on styles of forest road construction and maintenance is presented in the following paragraphs.

Achieving policy goals of forest road management can be accomplished in several ways. Forest Practices Rules may be mostly prescriptive (i.e., mandating specific aspects such as culvert spacing), or mostly performance oriented, where landowners are required to meet the overall objective of the rules, or both. Rules may contain language that allows for flexibility in road construction and maintenance. The language may be referred to as "discretionary," because it leaves some aspects of road management at the discretion of the landowner and/or the DNR.

In prescriptive rules, the specificity of the prescriptions allows for certainty of compliance and for relatively simple compliance monitoring. However, prescriptive rules may not be appropriate in specific cases and resource damage can occur even though the rules are applied. With part of performance-oriented regulations, resource protection is more directly addressed, but more intensive compliance and effectiveness monitoring are required to accomplish policy goals. Without follow up through compliance and effectiveness monitoring, uncertainty may arise about completeness of a landowner's actions, and about the adequacy of the prescriptive measures adopted by the landowner. Thus, the risk of sediment delivery can be assessed by evaluating the protection levels defined by performance criteria, the specificity of performance criteria, and how the performance criteria are followed up with monitoring.

In the previous section, the recommended practices for various aspects of road management were summarized. These are also referred to as best management practices, or 'BMPs'. In the following sections, the relative certainty of effectiveness is assessed for each of the three alternatives, along with the specifics of the guidelines or BMPs themselves. Table 1 provides a summary of the recommended BMPs, which processes are affected by them, and how each of the alternatives addresses them. It is important to note that implementation of BMPs is site-specific; recommended BMPs may not always be appropriate depending on local conditions.

For this analysis, it was assumed that increasing the opportunity for review by the regulating body (DNR) and outside groups decreases the risk of sediment delivery; this is a way of ensuring that policy goals are met. Furthermore, we assume that some activities will be conducted which are not explicitly stated as part of the proposed Forest Practices Rules. For example, although there are no provisions in the proposed Forest Practices Rules for checking the completeness of road maintenance plans, it is assumed that the DNR will ensure reasonable completeness of each landowner's plan through proper review and by inherent knowledge of local road problems. Notably, the conditions on which the assumptions are based may change over time.

Road Planning

Alternative 1

Because of the importance of planning in the prevention of sediment delivery, regulations with well developed, specific guidelines for road planning have a relatively low risk of sediment delivery. Under the existing forest practices, there is much consideration of the proper location of roads. For example, they state "fit the road to the topography so that a minimum of alterations to the natural features will occur" (WAC 222-24-020(1)). However, much of the language used in reference to road planning is discretionary. Direction is provided to landowners, but few specific measures are required. There is currently an extensive application and review process to ensure that the intent of the regulations is followed. While agency review in most situations resolves the most significant issues, the certainty with which regulations can be enforced is somewhat limited. Rashin et al. (1999) recognized the limitations of the discretionary language in existing regulations, and recommended eliminating it.

With respect to recommended BMPs, forest practices applicants are encouraged to avoid building roads in narrow canyons, riparian zones, on unstable slopes, and in wetlands, and to minimize the total length of new roads. However, there are no specific requirements to avoid sensitive areas. Because of the use of discretionary language, there is a risk of sediment delivery due to improper siting of roads.

Alternative 2

Policy objectives would be substantially different than under the current permanent Forest Practices Rules. These objectives include: maintenance of passage for fish in all life stages, passage of some woody debris, meeting water quality standards, sediment control, streambank protection, and directing road surface runoff to the forest floor. These policy objectives would provide a framework for the administration of the BMPs contained within the proposed Forest Practices Rules.

The Forest Practices Board Manual provides further guidance for road building practices. Stream- or wetland-adjacent roads would be located greater than 100 feet from streams or wetlands unless other alternatives would be more damaging to public resources. The Forest Practices Board Manual also recommends minimizing stream crossings through proper planning.

Rules regarding road planning (not road design) would be similar to those under current permanent Forest Practices Rules. Policy goals, however, would be more specific. These goals allow enforcement of policy and development of new strategies to achieve goals, should the specified strategies fail. This would result in a lower risk of sediment delivery relative to Alternative 1.

Alternative 3

Under this alternative, there would be no net increase in roads within an ownership or within a watershed. This would significantly affect road planning. Whenever a new road is proposed, an equivalent amount of road on the same property or within the same basin would have to be abandoned. Abandonment planning and procedures would be the same as under Alternative 2.

Stream crossings would be removed, the road surfaces would be outsloped, and waterbars would be installed to ensure that the roads do not contribute sediment to the stream systems.

Because the total miles of road would not increase under this alternative, the risk of road failure and surface erosion would decrease relative to current regulations, and relative to Alternative 2.

Road Design

Alternative 1

Current regulations lack several highly recommended BMPs for minimizing road surface erosion and road failures. These include using the outsloping of roads as the preferred surface drainage design, rather than having a hillside ditch. This was specifically recommended by Weaver and Hagans (1994).

As discussed under Road Design in the section on Recommended Forest Road Construction and Maintenance Practices, full-bench construction in steep areas is recommended in the literature to reduce the risk of road-related mass wasting. Under this alternative, there would be no requirements for full-bench design in steep or unstable areas (although in high hazard areas landowners are required to submit a Class IV – special application that undergoes SEPA review). Another recommended BMP is to minimize sidecast construction of roads. While the current regulations encourage landowners to balance fill and excavation so that as much fill as possible is used on the fill section, they do not specifically mention avoidance of sidecast construction. Similarly, there is no direction provided to minimize the length and width of cut and fill slopes, which would reduce the risk of surface erosion and road failure.

New road crossings of fish-bearing streams currently require a Hydraulic Project Approval, which is administered by the WDFW. While the current regulations partially address fish passage issues, one recent study indicates that passage barriers remain a persistent problem (Rashin et. al., 1999), although old stream crossings account for many of the barriers. Under this alternative, fish passage through stream crossings, particularly existing stream crossings, is expected to remain a problem.

Alternative 2

Under this alternative, several important changes to the regulations would occur. One of the most important would be the requirement of full-bench road design on slopes greater than 60 percent. This is much more specific than under current regulations, and is strongly recommended by Weaver and Hagans (1994). This generally reduces the risk of surface erosion and road failure, relative to the current regulations. The remaining BMPs relevant to sediment delivery would be the same as under Alternative 1.

The Forest Practices Board Manual contains a list of general guidelines to be followed in the road design process. This includes: avoiding the rerouting of streams; installing cross drains; armoring cross drain outfalls where the flow would be erosive; constructing catch basins or sediment traps; outsloping of roads where possible; and using gravel surfacing of appropriate thickness. These guidelines, assuming they are followed, would substantially reduce the risk of sediment delivery to streams, relative to Alternative 1. Policy goals allow the enforcement of these guidelines or more restrictive measures if potential for damage to resources exists.

Under this alternative, road maintenance plans would be required which prioritize replacement of streams crossings that block fish passage. There would be no specific requirements for replacing or reconstructing stream crossings to improve fish passage. However, the requirements of road maintenance and abandonment plans would improve the knowledge of the extent of poorly designed culverts, and would encourage landowners to replace or reconstruct such crossings. This would reduce the extent of fish passage barriers. As under Alternative 1, a Hydraulic Project Approval (from WDFW) would be required on new crossings of fish-bearing streams.

Alternative 3

With respect to design-related BMPs, this alternative would have the same effects as Alternative 2.

Road Drainage

Alternative 1

Under this alternative, several deficiencies in the regulations previously identified would continue to allow sediment delivery to streams.

The first set of BMPs relates to road surface drainage. Recommended BMPs include rolling grade dips, water bars, and grade dips at stream crossings. The first two are low maintenance methods of dispersing road-generated runoff. Rolling grade dips are encouraged under Alternative 1; however, there are no specific rules for them. Water bars and grade dips at stream crossings are not mentioned in the regulations.

The second set of relevant BMPs concern culverts. Culverts, used for drainage ditch relief and for stream crossings, have in the past been undersized, leading to overtopping and failure. Rashin et al. (1999) found that ditch relief culverts were only partially effective as installed under the current permanent rules. These culverts often deliver road-generated sediment to streams (Rashin et al, 1999); instead of dispersing flow onto the forest floor, it is often quickly returned to the nearest stream. In addition, the outlets commonly are eroded. This occurs even though the regulations encourage armoring at the outlet to protect against erosion. Trash racks are currently not required, although WDFW may require them on streams that are subject to Hydraulic Project Approvals. Since the debris carried by some streams may be too large to pass through the culvert, even when designed for the 50-year storm, it is essential to have a way of protecting the inlet. Based on Weaver and Hagans (1994), the lack of trash racks significantly increases the risk of stream crossing failure. In addition, the spacing of ditch relief culverts is wider than that recommended in the literature. This has led to ditch erosion and excess flow in some circumstances, which delivers sediment to streams (Rashin et al., 1999). This alternative would result in a continued risk of sediment delivery to streams.

Sizing of culverts is also important. Current regulations require sizing of culverts using a table of recommended sizes. If the DNR determines the need for larger culverts, a nomograph is used, which requires the discharge to be calculated. There is no specific guidance on calculation of flood discharge. Because there is no requirement for calculation of flood discharge, this alternative contains a significant risk of road topping (and consequent failure) due to the potential undersizing of culverts.

Alternative 2

The main difference between the proposed action and Alternative 1 is the new, closer spacing of ditch relief culverts that would be required. The Forest Practices Board Manual contains guidelines for determining culvert spacing. These guidelines use road grade, region (east side and west side), percent sideslope, average distance above the nearest stream, road condition and use, precipitation, and soil erodibility to determine culvert spacing. The maximum culvert spacing, not accounting for any of the above factors, would be 1,000 feet. The spacing guidelines reduce the maximum spacing by an amount that depends on each factor. The result is that in the majority of situations, culvert spacing would be within the spacings recommended by Weaver and Hagans (1994). The new rules would also require ditch relief culverts to be placed such that flow is dispersed across the forest floor before reaching streams. The Forest Practices Board Manual would contain guidelines for achieving this.

While the closer spacing of culverts is highly recommended, a number of other drainage-related BMPs remain as under Alternative 1. Policy goals are specific enough to allow DNR to minimize damage to public resources through BMPs that are not specified in the rules; although compliance and effectiveness monitoring is unclear. Nonetheless, the risk of sediment delivery would be slightly lower than under current conditions.

Alternative 3

Because requirements with regard to drainage would be identical to those under Alternative 2, the effects would be the same as Alternative 2.

Road Construction

Alternative 1

Under this alternative, several important BMPs are relevant. Erosion during construction has been found to be a significant source of sediment delivery (Rashin et al., 1999). Erosion control methods are encouraged under this alternative, as found in WAC 222-24-030(4): "When soil, exposed by road construction, appears to be unstable or erodible and is so located that slides, slips, or sediment may reasonably be expected to enter Type 1, 2, 3, or 4 water, and thereby cause damage to a public resource, then such exposed soil areas shall be seeded with grass, clover, or other ground cover, or be treated by erosion control measures acceptable to the department." Notably, there are no erosion control specifications.

In addition, limiting earth-disturbing activities during rainy periods is an important component of erosion control. Current Forest Practices Rules limit these activities to periods "…when moisture and soil conditions are not likely to result in excessive erosion and/or soil movement, so as to avoid damage to public resources." There are no standards for landowners to judge when excessive erosion would occur, and no statement of level of acceptable risk to public resources. Thus, there is a high degree of uncertainty regarding the effectiveness of this Forest Practices Rule in preventing sediment delivery to streams. Another basic BMP for erosion control during timber harvest activities is to minimize the amount of soil disturbance (Weaver and Hagans, 1994). There is no guidance in the current Forest Practices Rules to limit soil disturbance.

The two BMPs above are usually included in erosion and sediment control plans, which are required on other types of construction projects in many parts of western Washington; county regulations often require a submittal of an erosion and sediment control plan (ESCPs). However, ESCPs are not required under this alternative.

Current Forest Practices Rules do require that sidecast not be placed within the 50-year flood level (based on 1.25 times the stream depth at the ordinary high water mark). This helps reduce direct contribution of sediment from road construction. Current Forest Practices Rules also require that no organic debris be incorporated into the roadbed. This BMP reduces the risk of road failure and subsequent sediment delivery.

Overall, however, there are few specifications or guidance on erosion control measures during construction. Thus, there is a continued risk of sediment delivery under this alternative.

Alternative 2

There are two differences in the BMPs for road construction between Alternative 1 and Alternative 2. The new regulations would require that disturbed areas "where it [soil] could reasonably be expected to enter the stream network" be seeded with non-invasive plant species. Under Alternative 1, invasive plant species could be used. As under Alternative 1, there are no specified seed mixture, application rate, or mulching, or other erosion control measures typically contained in an ESCP.

The other difference is that sidecast must not be placed within the 100-year flood level, rather than the 50-year flood level as under Alternative 1. The method for determining the 100-year flood level is specified in the Forest Practices Board Manual and is presumed to be the method that would be used for permanent rules. The 100-year flood level is determined by multiplying the bankfull depth by 1.8. This method is based on regional flood factors (see Forest Practices Board Manual for Emergency Rules - 03/2000). This restriction should reduce the risk of sediment delivery relative to Alternative 1.

With the exception of these two BMPs, rules regarding construction are similar to those under Alternative 1, and the new specifications contain some discretionary terms. Assuming policy goals are implemented, additional BMPs will be required to minimize damage to public resources. Therefore, the risk of sediment delivery would be reduced relative to Alternative 1.

Alternative 3

The BMPs under this alternative are similar to those under Alternative 2.

Road Maintenance and Abandonment

Alternative 1

Under this alternative, submittal of road maintenance and abandonment plans (RMAPs) to the DNR is required upon request. Under these rules, each landowner could have very different maintenance plans. The regulations require that the landowner include maps showing all roads, active, inactive, and orphaned, or abandoned. However, there are no specifications for maintenance and abandonment plans. There are no provisions for the maintenance of ditches, culvert inlets, road surfacing, or stream crossings. Although this alternative provides for agency review, there is still a level of uncertainty with regard to its effectiveness.

Notably, orphaned roads are not addressed under this alternative. Orphaned roads are defined as roads or old railroad grades that have not been used since 1974. These roads are not maintained, and were built and last used prior to the regulation of roads under the Forest Practices Act. As a result, they are subject to mass wasting and erosion, and can be a major source of sediment within a watershed. Therefore, there would continue to be a risk of sediment delivery under this alternative.

Alternative 2

This alternative provides significantly more direction for landowners than under current rules. Performance criteria are contained in a new section of policy and under guidelines for road management. Road maintenance and abandonment plans (RMAPs) would be required of landowners with greater than 500 acres of forest land. Landowners with less than 500 acres of land would be required to submit RMAPs when they submit their next forest practices application. Completed RMAPs would be required by 2005. Each landowner would have to include at least 20 percent of their roads in the RMAP each year. Those owners whose land is covered by a watershed analysis could follow road prescriptions from the analysis. However, less than 10 percent of all Watershed Administrative Units currently have completed analyses (see Appendix G). Therefore, most landowners would be required to submit RMAPs. Notably, all forest roads would have to meet the standards of the WAC 222-24 within 15 years of the issuance of the rules.

The regulations under this alternative provide more specific guidance on the content of RMAPs, without listing specific maintenance techniques. Each landowner must submit, as part of the RMAP, standard practices, pre-storm planning, emergency, and post-storm restoration practices, an inventory of risks to public resources, and a detailed work plan. While the RMAP would be required for the entire ownership by 2005 (or five years after the rules take effect), all work described in the RMAP would be required to finished within 15 years of adoption of the new rules. The submittal and review process for RMAPs would be much more explicit under this alternative than under current rules. This includes annual meetings with all jurisdictional and interested parties. In addition, annual progress reports would be required to be submitted to the DNR, detailing work accomplished, and work postponed or delayed.

Orphaned roads are addressed under this alternative. Landowners are required to inventory orphaned roads and assess the risk to public resources. While landowners would not specifically be required to fix problems associated with orphaned roads, it is assumed that risk to public resources, which is to be reported in the road maintenance plans, would provide incentive for this work.

Guidance on road use is provided in the Forest Practices Board Manual. The list of recommended BMPs includes: minimizing operation of tracked equipment (such as bulldozers) on haul roads; use of central tire inflation-equipped trucks (reduces damage, and sediment yield, on road surfaces); close or limit traffic during periods of freeze/thaw or heavy rain; seasonal or permanent road closures in selected areas. The Forest Practices Board Manual also contains guidelines for maintenance. The extensive list of guidelines address road surface, ditch, and cutslope maintenance. One of the most important guidelines is to keep ditches free of woody vegetation, but maintain grass cover. There are guidelines for active and inactive roads.

While these are guidelines, and not specific rules, the required road maintenance plans must address the issue of road use generally, and landowners would have an incentive to adopt the guidelines. In addition, once roads are identified for abandonment, they would be required to be abandoned. Follow-up monitoring of compliance is unclear. There would be no specific requirements for checking completeness of road maintenance surveys or fish passage problems. Additionally, there are no provisions for evaluating the effectiveness of any BMPs landowners may propose. However, because of the explicit requirements for maintenance and abandonment, and the additional guidance from the Forest Practices Board Manual, this alternative would substantially reduce the risk of sediment delivery from existing and future roads.

Alternative 3

Under this alternative, road maintenance and abandonment would be regulated as under Alternative 2, except that all work identified in the road maintenance and abandonment plans would be required to be finished within 10 years. The effect would be a more immediate reduction of the risk of sediment delivery from roads than under Alternative 2.

References

Best, D.W., H.M. Kelsey, D.K. Hagans, and M. Alpert. 1995. Role of Fluvial Hillslope Erosion Sediment Budget of Garrett Creek, Humboldt County, California. In: K.M. Nolan, H.M. Kelsey, and D.C. Marron (editors), pp. M1-M9. *Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California*. U.S. Geological Survey Professional Paper 1454.

Bolda, S.K. and W.J. Meyers. 1997. Conducting a Long-term Water Quality Monitoring Project: A Case Study on the McCloud River, California. Soils and Water Conservation. 53 (1): 49-54.

Brunengo, M., and Bernath, S. 1990. Orphan Roads Program – Hazard and Risk Assessment. Dept. of Nat Res., Forest Practices Division Open File Report 90-1.

Cederholm, C.J., and L.M. Reid. 1987. Impacts of Forest Management on Coho Salmon (*Oncorhynchus kisutch*) populations of the Clearwater River, Washington: A Project Summary. In E.O. Salo and T.W. Cundy (editors*). Streamside Management: Forestry and Fishery Interactions*. Proceedings of a symposium. Institute of Forest Resources, University of Washington, Seattle, pp. 373-398.

Chamberlin, T.W., R.D. Harr, and F.H. Everest. 1991. Chapter 6: Timber Harvesting, Silviculture, and Watershed Processes. In Chapter 6: Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19, pp.181-205.

Dunne, T., and Leopold, L. 1978. Water in Environmental Planning; New York: Freeman and Company, 815p.

Duncan, S.H., Bilby, R.E., War, J.W., Heffner, J.T. 1987 Transport of road-surface sediment through ephemeral stream channels; Water Resources Bulletin, v.23, n.1; pl. 113-119.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and Maintenance, in W.R. Meehan, Ed., Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Pub. 19, Bethesda, Maryland, p.297-324.

Harr, R.D., and R.A. Nichols. 1993. *Stabilizing Forest Roads to Help Restore Fish Habitats: A Northwest Washington Example*. Fisheries, Volume 18, No. 4, pp. 18-22.

Megahan, W.F., and W.J. Kidd. 1972. *Effects of Logging and Logging Roads on Erosion and Sediment Deposition from Steep Terrain*. Journal of Forestry 70:136-141.

National Marine Fisheries Service. 1998. A Draft Proposal Concerning Oregon Forest Practices.

Nolan, K.M, and R.J. Janda. 1995. Impacts of Logging on Stream-Sediment Discharge in the Redwood Creek Basin, Northwestern California. In: K.M. Nolan, H.M. Kelsey, and D.C. Marron (editors), pp. L1-L10. *Geomorphic Processes and Aquatic Habitat in the Redwood Creek Basin, Northwestern California*. U.S. Geological Survey Professional Paper 1454.

Rashin, E., Clishe, C., Loch, A., Bell, J. 1999. Effectiveness of Forest road and Timber Harvest Best Management Practices with Respect to Sediment-Related Water Quality Impacts; Washington State Department of Ecology, Olympia, WA 118p.

Washington Department of Natural Resources. 1997. Forest Practices Board Manual Standard Methodology for Conducting Watershed Analyses, Olympia, WA version 4.0.

Weaver, W.E., and D.K. Hagans. 1994. *Handbook for Forest and Ranch Roads: A Guide for Planning, Designing, Constructing, Reconstructing, Maintaining, and Closing Wildland Roads*. Prepared by Pacific Watershed Associates for the Mendocino County Resource Conservation District in cooperation with the California Department of Forestry and Fire Protection and the USDA Soil Conservation Service. June 1994. 161pp.

Yee, C.S., and Roelofs, T.D. 1980. Planning forest roads to protect salmonid habitat, in Influence of Forest and Rangeland Management on Anadromous Fish Habitat in Western North America, Meehan, W., ed., USDA, Pacific Northwest Forest and Range Experiment Station General Technical Report PNW-109 26p.